

finer texture, approaching that of the lower wings. The claws of the tarsi are strong, powerful, and well adapted for clinging.

In this animal we seem to have a combination of two plans of adhesion: there are the claws and claspers and flaps for holding on by; there is the hollow underside for adhering by exhausting the air between it and the stone it clings to, on the principle of the air-pump. If, when it settles on the stone and adjusts itself, its tracheæ are full of air, and it then expels the air and by muscular power draws in the skin of the abdomen and underside generally, it must, of course, leave a vacuum, and consequently adhere like a sucker.

This species from the mountains of Brazil is the only one of whose aquatic habits any account has been received; but the genus, although individuals are rare (as with most species which only show themselves at night), is widely distributed.

The following are the species known up to the present time, with their localities, taken from Westwood's recent Monograph of the Phasmidæ:—

<i>Prisopus flabelliformis</i> , Stoll.	Brazil; Cayenne.
— <i>spiniceps</i> , Burm.	Do. do.
— <i>Ohrtmanni</i> , Licht.	East Indies.
— <i>horridus</i> , Westw.	Columbia.
— <i>Horstokkii</i> , De Haan.	Cape of Good Hope.
— <i>berosus</i> , Westw.	Panama.
— <i>phacellus</i> , Westw.	Brazil; Ega.
— <i>incertus</i> , Westw.	Samarang; Java.
— <i>cornutus</i> , G. R. Gray.	India.
— <i>cepus</i> , Westw.	Bolivia.
— <i>Guerini</i> , Westw.	Ile Maurice.

Now that their habits are made known, we may expect that specimens will become less rare, and that we shall receive more information regarding their economy and mode of life.

XXXV.—On Two European Argulidæ, with Remarks on the Morphology of the Argulidæ and their Systematic Position, together with a Review of the Species of the Family at present known. By T. THORELL.

[Continued from p. 169.]

III.

As the question of the position which the family Argulidæ should occupy in the system of the Crustacea is far from having received a satisfactory solution, it will not be out of place here to dwell somewhat further on this subject. Referred by Linné

to the genus *Monoculus* (which corresponds with almost all the lower Crustacean orders or "Entomostraca" with the exception of the Cirripeds), the sole representative of the family Argulidæ then known (*A. foliaceus*) held a place in the 'Syst. Nat.' ed. 10, between *M. polyphemus* and *M. apus*, consequently between a *Limulus* and an *Apus*. In the 'Fauna Suecica,' ed. 2, a *Caligus* (*M. piscinus*, L.) was located between *Argulus* and *Apus*. In the 'Entomostraca' of Müller*, who first erected the genus *Argulus*, we find it between *Polyphemus* and *Limulus*, immediately after which comes the genus *Caligus*.

From this time, however, it gradually became general to place *Caligus* and *Argulus* near to each other, especially since Latreille laid the foundation of the present prevalent division of the class of Crustacea, and constituted the order Siphonostoma for those forms which are provided with sucking-tubes, placing therein the genera *Argulus* and *Caligus* in close proximity to each other. This view of the systematic position of the Argulidæ has been shared by most of the more modern authors, as Burmeister, Milne-Edwards, Baird, Dana, Heller, Cornalia, Claus, Kröyer, &c. As Latreille's *Siphonostoma* and Milne-Edwards's *Lernéides* have been united with that author's *Copépodes* in a single order by Zenker†, under the name Entomostraca, called *Copepoda* by later authors, it is consequently among the parasitic suctorial Copepoda (Copepoda siphonostoma) that the nearest affinities of the Argulidæ have been sought. But this view of the affinities of the Argulidæ has been by no means generally accepted: from more than one quarter have objections to it been put forward, which render necessary a further examination of the reasons alleged in favour of it. Dana and Herrick have already pointed out the great differences between the oral organs of the Argulidæ and the true Siphonostoma, and express their opinion that *Argulus* should perhaps hereafter become the type of a new order, standing between the Siphonostoma and the Pœcilopoda or Xiphura. Their attempt to show a nearer relationship between the Argulidæ and these last must, however, be regarded as abortive, since it is pretty generally recognized that such conditions of organization as may ally the Argulidæ to *Limulus* are presented in a still more marked degree by the Phyllopoda, especially the genus *Apus*. *Limulus* shows, moreover, so many remarkable peculiarities in its structure, that it must necessarily be regarded as the type of a separate order, in spite of its being more nearly related to the Branchiopoda and

* Entomostraca seu Insecta testacea, quæ in aquis Daniæ et Norvegiæ reperit, &c. O. F. Müller (1785), p. 121.

† Untersuchungen über die Organisation und Verwandtschaft der Copepoden, p. 54.

Argulidæ than to any other group of the Crustacea. Even Vogt expresses himself against the union of the Argulidæ with the Siphonostoma, on the ground that the organization of the mouth is very different; but he says nothing further as to their place in the system.

The order Branchiopoda only can claim a stronger affinity to the Argulidæ on the ground of several leading points of resemblance. The relation of these latter to that order had already attracted the notice of authors who ranged them with the Siphonostoma, as, for instance, Milne-Edwards, who says, with reference to the swimming-feet of the Argulidæ, that they seem to be intermediate between those of the Branchiopoda and of the ordinary Siphonostoma. Zenker is, however, the first who made a decided step in this direction, and in his Crustacean system united them with the Branchiopoda, at the same time drawing attention to their marked agreement with these in certain important points, as the structure of the eyes and digestive apparatus, and showing also that the greater number of the characters which were thought to justify their amalgamation with the Copepoda are also to be found in many Branchiopoda. This notion of Zenker as to the systematic position of the Argulidæ has been shared by Gegenbaur and myself*, as also by Steenstrup and Luetken, who ally *Argulus* to the Phyllopoda, as the representative of parasitism in that group.

A renewed examination of the structure of the Argulidæ, as compared with that of the Copepoda and the Branchiopoda, has further convinced me of the correctness of Zenker's view. I have fancied that I could discover grounds for making the Argulidæ a suborder of the Branchiopoda, consequently *a group of equal value with the Phyllopoda and Cladocera*, although most nearly allied to the former; and as I shall now proceed to an exposition of those grounds, I have only to hope that such may in some measure contribute to the final solution of the question. Such an examination has appeared to me all the more necessary since Krøyer has lately become a champion of the old view of the position of the Argulidæ, and has sought to prove their affinity with the Copepoda by several considerations which have been more or less overlooked by previous authors, who founded their ideas of the propriety of inserting the Argulidæ among the parasitic Copepoda exclusively on the suctorial formation of the mouth and the parasitic habits depending thereon.

In order to form a clear notion of the relations of the Argulidæ to the Copepoda and Branchiopoda, it is necessary to determine the reciprocal relations of these two groups; *i. e.* to

* "Bidrag till kännedom om Krustaceer, som lefva i arter af släktet *Ascidia*, L.," K. Vetensk.-Ak. Handl. Bd. iii. No. 8 (1859-1860), p. 14.

define what is common to both types and what are the principal characters which authorize their position as two distinct orders in the class, and then to see in what respect the Argulidæ assimilate to the one or the other group, or differ from both. We will, in passing, merely recall the common bond which unites all the lower orders of Crustacea, Xiphura, Branchiopoda, Ostracoda, Copepoda, and Cirripedia, and which seems to us to warrant the union of these orders into one large subclass, Entomostraca, in Latreille's acceptation of that term, in contradistinction to the other, higher Crustacean orders, or Malacostraca. The Xiphura incline towards the Phyllopods in the order of the Branchiopoda, with which Zenker was disposed to unite them; the near affinity of the Ostracoda with the Cladocera is pretty generally recognized; moreover they are often placed in close connexion with the Copepoda; and these latter show not only a great affinity with the Ostracoda, but also with the Cirripedes on the one side, and the Branchiopods, especially the Phyllopods, on the other.

This near relation of the Copepods and Phyllopods shows itself especially in their development. In both groups, the larva, as far as is known, always goes through a *Nauplius*-stage, and then shows three pairs of extremities of which the first two develop into the first and second pairs of antennæ, the third into the mandible and its palp when such exists. The body is always (except in the lower parasitic Copepods) conspicuously segmented; the oral organs consist, when complete, of four pairs of appendages—one pair of mandibles, one pair of maxillæ, and two pairs of foot-jaws. The feet are cloven or lobed swimming or respiratory organs. The Cladocera differ in their indistinctly segmented trunk, and in the fact that they go through the metamorphoses which correspond to the *Nauplius*-stage in the egg, and thus *do not* go through a (true) metamorphosis. In this respect they approach the Ostracoda. The development of the Argulidæ is midway between that of the Phyllopods (and Copepods) on the one side, and that of the Cladocera (and Ostracoda) on the other: their larvæ go through the earlier phases of the *Nauplius*-stage in the egg-shell, and quit this in a form which most nearly corresponds with what Claus calls the final *Nauplius*-stage of the Copepoda; whence the metamorphoses of the Argulidæ, as compared with those of the Phyllopods and Copepods, may be called *incomplete*. For the rest, we find in the Argulidæ also those characters which we have mentioned as common to Phyllopods and Copepods.

If we would determine by what characteristics the Copepods and Branchiopods may always and with certainty be distinguished from each other, we cannot at the outset fail to per-

ceive that the former constitute a much compacter whole than the latter, and that certain conditions of organization which in the one type (that of the Copepoda) show a considerable degree of constancy are in the other exceedingly variable. Thus the number of body-segments in the Copepods varies within comparatively narrower limits than in the Branchiopods; and the same thing is the case, and in a higher degree, with the number of the legs. Since the trunk in Copepods always bears a definite number, at the most (and most frequently) five pairs, of extremities, it would be an extremely remarkable variation if a form appertaining thereto were detected with more than five pairs of legs; whereas it is not at all surprising to meet among the Branchiopods, which certainly are generally distinguished by numerous extremities, with forms possessing only a few pairs of legs (as, for instance, four in the Argulidæ), while their number varies in the Phyllopods from ten to sixty, and in the Cladocera goes down to six, five, or only four pairs.

The oral organs also are more constant in number in the Copepods than in the Branchiopods, where the maxillary feet are mostly rudimentary or entirely wanting. Even in cases where both pairs are found, as in *Apus*, the posterior are always rudimentary—a condition which is seldom observed in the Copepods. Amongst these it is usually only in connexion with parasitic habits that the number of the oral organs is reduced; but it is here worthy of remark that *the parasitic nature in general occasions a stronger development of the maxillary feet, and always in those groups at least which possess suctorial tubes and distinctly segmented bodies* (i. e. Ascomyzontidæ, Caligidæ). This would lead us to suppose that if parasitic Branchiopoda be found analogous to the Copepod families just named, the maxillary feet of these, as constituting the seizing-organs already mentioned, will also have received a stronger development than in the free forms. Notwithstanding, therefore, that the Argulidæ possess, as is well known, in correlation with their parasitic habits, particularly strong maxillary feet, this character would not forbid their approximation to the Branchiopoda on the ground of their further agreement with that group.

In the Copepoda both mandibles and maxillæ are usually furnished with a palp, whereas this is never the case in the Branchiopod order, excepting in the genus *Nebalia*, which differs in so many respects from them, and makes an approach to the Decapoda (*Mysis*, *Cuma*). In Copepods the palpi are certainly sometimes wanting, especially in the parasitic forms; but in the higher Siphonostoma (Ascomyzontidæ and Caligidæ) there is generally at least *one* pair, while these organs are altogether wanting in the Argulidæ.

Here it will be proper to make the two following remarks:—

In the parasitic suctional Copepoda, the tube never contains more than one pair of organs, the mandibles; in the Argulidæ, on the contrary, most generally two pairs, both maxillæ and mandibles, and these in form quite unlike the small saw- or lancet-like mandibles of the Siphonostoma.

In the parasitic Copepoda it is always the antennæ of the *second* pair which are used as seizing-organs; in the Argulidæ, on the contrary, it is the *first* pair which performs this function.

As something peculiar to the order Copepoda, the form of the *limbs of the trunk* holds a prominent place. These consist, as we know, of a basal piece, composed of two joints, with two branches situated on this, each consisting of three joints. Generally the feet belonging to one pair are united by means of a *median plate*, so that they move in unison. The structure of the legs may perhaps be simplified by certain parts becoming fused together or further separated; but whenever the legs attain a full development, they present the form here described. Such is also the case with the parasitic forms—as, for instance, the Caligidæ. In the Branchiopoda the structure of the legs is highly variable, but is still referable to a common type: it is sufficient to notice here that they never have the form characteristic of Copepoda, and that the *median plate is always absent*. This is also the case in the Argulidæ, whose swimming-feet, as we shall show further on, admit of an easy comparison with the feet in *Apus*. The presence of “branchial appendages” on the feet of the Branchiopoda is not a thoroughly constant character in this order: they are wholly rudimentary or completely wanting in many Cladocera, as *Polyphemus*, *Podon*, *Evadne*, *Bythotrephes*, *Leptodera*, on the extremity of the tail in *Nebalia*: consequently the absence of such appendages in an animal (as in *Argulus*) does not show that it cannot belong to the Branchiopoda.

Almost as distinctive of the Branchiopoda as the form of the feet in the Copepoda is the structure of the *visual organs* in the former as compared with the latter. The Branchiopods have two large, generally moveable, lateral eyes (in the Cladocera these coalesce into a single eye), composed of numerous crystalline cones, with the cornea at least externally unfacetted. No Copepod has eyes that can be fully compared to these; for the median single eye in the Copepod, which often contains two or more crystalline bodies, corresponds to the ocellus situated behind the lateral eyes in the Branchiopoda, and sometimes also provided with crystalline bodies; and the large paired eyes in certain Copepods (as the Pontellidæ and Corycæidæ) show a structure entirely different from the compound eyes of the Branchio-

poda, if indeed they morphologically correspond with these. The eyes in *Argulus* are moveable, and agree in their structure, as is well known, with those of the Phyllopods in their most sharply defined form.

In the Copepoda we never meet with the *shell armature* which, as a kind of supplementary integument on the anterior divisions of the body, in the Branchiopoda so generally encloses or covers the body. The large *shield* in the Argulidæ shows the greatest resemblance to the carapace in *Apus*, and removes them far from the Copepoda.

With regard to the *internal structure*, this in many instances affords a more uncertain criterion for judging of the affinity of the lower Crustaceans than do the characters which are drawn from their external form. Thus the nervous system, the circulatory apparatus, &c., in nearly related forms, may show very striking discrepancies, to adduce an instance of which we will only mention the known fact that, even in the strictly natural group formed by the gnathostomous Copepods, the Calanidæ and Pontellidæ possess a heart, while the nearly allied Cyclopidae, with others, want a definite central organ of circulation. At the same time, however, that the internal structure presents such extraordinary variation and inconstancy even in the most nearly related groups, it shows, on the other hand, in its general features such striking correspondences in the Branchiopods and Copepods, that it is difficult to fix any anatomical character as belonging to one only of these two orders. The *generative apparatus* in the Copepoda only furnishes two peculiarities which are worth noticing here. The *eggs* are united in the Copepoda, when they leave the ovaries, to form one or two *external egg-sacs*, excepting in the spurious parasitic Notodelphyidæ and Buproidæ, in which they are received into a *matrix*, almost as in the Cladocera. In the Branchiopoda such egg-sacs are *never* present. In the Copepoda, impregnation takes place, as far as we know, always by means of *spermatophores*, which are attached externally to the body of the female close to the sexual orifice or the mouth of a separate canal leading to the receptacle. The Branchiopoda *never* show such spermatophores. In both these points the Argulidæ depart from the Copepoda in general, and from the analogous forms in that order, Caligidæ and Ascomyzontidæ in particular, in that they lack both egg-sacs and external spermatophores.

Notwithstanding the agreement which the Argulidæ present with the Branchiopoda in respect to conditions of propagation, they yet exhibit in this very direction both peculiarities and analogies with other orders. Zenker has already pointed out this: in respect to the form and products of its generative ap-

paratus, he says that *Argulus* makes a nearer approach to the Ostracoda "in its thread-like zoosperms and the existence of male accessory glands and of female seminal receptacles." He might have added that they here also approach the Copepoda, which are also sometimes furnished with thread-like zoosperms (I myself have observed them in *Lichomolgus*); accessory glands are often met with in connexion with the male organs, and a single or double receptaculum seminis apparently always, in the Copepoda. Resemblances in these particulars, with the exception of the last named, are, however, relatively of little weight. Meanwhile the generative apparatus in the Argulidæ is referable, as we have seen, in certain points to the Branchiopods, in others to the Copepods. But conditions in the highest degree peculiar separate them from both these orders. Unfortunately, much respecting the propagation of the Argulidæ remains still obscure; and even Leydig's accurate researches on this subject* leave many important questions unanswered. The signification of the characteristic (probably copulatory) appendages on the two or three posterior pairs of swimming-feet is undetermined, with the exception of the capsule on the hinder part of the third pair of feet, which, according to Leydig, is filled with sperm from the opening of the ductus deferens, and afterwards, during the act of copulation, presses its contents into the seminal reservoirs. The function which belongs to the "hook" on the last pair of legs, which in its structure so strongly recalls the copulatory organ of the Spiders and *Julus*, is unknown. Leydig perceived only that during copulation this was "closely pressed upon or into the capsule of the last pair of legs but one," and that it did not serve in any way to retain the female. This latter function may perhaps belong to the projections on the hinder part of the second pair of legs, which occur in certain species, as *A. coregoni*. As to the significance of the projections on the fore part of the third pair of feet, I do not venture to guess.

The females of the Argulidæ have, as has been said, two receptacula seminis, which, each by means of a proper channel of communication, opens out on a moveable papilla near the underside of the tail, behind the mouth of the ovarium; and thus it would seem that an immediate connexion between the receptacles and the ovarium is here wanting. How the semen under these conditions can come into contact with the eggs is still undiscovered.

Another circumstance also brought to light by Leydig (with reference to *A. foliaceus*) is of the greatest interest. "The receptacle is," he says, "in females which have never copulated, empty and folded inwardly. After copulation there appears in-

* Ueber *Argulus foliaceus*, p. 339 &c.

side this another stout vesicle, which is filled with spermatozoids. A homogeneous sharply defined thread shows itself as a continuation of the skin of this enclosed vesicle, through the outlet, to a papilla situated in a concavity." On the nature of this bladder nothing is said. But may we not see in this a *spermatophore* which is not, as in the Copepods, attached externally to the body of the female by means of a tubiform filament through which the spermatozoids pass into the receptacle, but which is altogether introduced into this latter? And if this supposition be correct, where is the spermatophore produced? Possibly, may we not think, in the capsule on the third pair of legs, whence it must be supposed to have become transferred to the receptacle? in effecting which the "hook" on the last pair of legs would certainly play an important part. Or may not the two accessory glands which open each upon the lower portion of its own ductus deferens contribute the secretion to form the walls of the spermatophore? And how can the spermatozoids escape from this bladder or spermatophore if the channel of communication be filled up by a "homogeneous thread"?

I have dwelt upon these circumstances chiefly with a view to drawing to them the attention of those who have opportunities and inclination to accord them a due investigation in living Argulids. Especially suitable for such researches is the large *Argulus coregoni*, which would seem to be tolerably frequent in the larger lakes of Sweden.

Proper to the Argulidæ is moreover the circumstance that the eggs come directly from the ovarium into freedom: they are neither retained in a "uterus," matrix, or any structure analogous thereto, as is the case in most Branchiopoda; nor are they attached to the projection of some of the legs, as in some forms of this order. (See what we have said concerning the ovarium of *A. coregoni*, p. 168.) This is, however, of subordinate importance. The ovarium of *Argulus* may be regarded as corresponding to both uterus and ovarium in, for example, *Branchipus*, forming, however, a single structure, in which the portions set apart for the producing of the eggs and for their maintenance have not yet become separated in position from each other.

The remaining peculiarities which the sexual apparatus of the Argulidæ presents are not of very great importance, and are always easily reducible to conditions commonly prevalent in the Branchiopoda. They are mostly to be accounted for by the fact that the tail is sharply separated from the trunk, whence also the various parts of the sexual apparatus are more separated from each other. Thus the ovarium is situated entirely in the trunk, while the receptacles are in the tail; the testes are placed

here, while the seminal bladder and ductus deferentes lie in the trunk. In the Branchiopods both ovarium and testes have their position in the anterior portion of the tail*.

While we are on the subject of the sexual conditions of the Argulidæ, we must not omit to mention a circumstance which in some measure removes them from the Branchiopoda: propagation by means of *parthenogenesis*, which seems to be so general in that order, seems to be as rare among the Argulidæ as among the Copepoda.

Among the anatomical characters whereby the Copepoda may pretty constantly be distinguished from the Branchiopoda, it has been asserted, is the *absence of gall-secreting branches in the intestinal canal*. However, according to Claus, many Copepods, especially the genus *Sapphirina*, possess extremely strongly developed glandular liver-appendages; and since these in many Branchiopoda (as, for instance, the Branchipodidæ) are but feebly developed or (as in *Limnadia* and many Cladocera) altogether wanting, we must not attribute to this character any special importance. Still the strong branches of the intestinal canal beneath the head-shield in *Apus* and *Argulus* certainly afford further grounds for considering that these creatures are nearly related.

Neither in the nervous nor circulatory system do I find any characteristics which might contribute to fix the line of demarcation between the Branchiopods and Copepods. The copious supply of blood in the head-shield in *Argulus*, which Zenker regards as attesting the Copepod nature of the Argulidæ, depends only on the strong development of this shield, the form of which meanwhile points, as has already been said, to a near relation with the Branchiopoda. According to Leydig and Claus, blood-corpuscles *are wanting* in the nourishing fluid of the Copepoda, but are found in both Phyllopoda and Cladocera, as also in *Argulus*. This difference, however, is not constant; for they are found also, according to Dana, in abundance in the Caligidæ in the first-named order. The well-marked separation of the tail from the trunk, and its *modification as a respiratory organ*, would seem to be the most prominent feature in their

* Leydig, "Ueber *Artemia salina* und *Branchipus stagnalis*, Beitrag zur anatomischen Kenntniss dieser Thiere," Zeitschrift für wissenschaftliche Zoologie, Bd. iii. p. 297 &c. Leydig is guilty of a misrepresentation when he says that Joly did not perceive the true ovaria of *Artemia salina*, but only the uterus, which he mistook for the ovary. Joly expresses himself thus:—"Sur les parties latérales des deux premiers anneaux de l'abdomen on s'aperçoit . . . deux sacs allongés, cylindriques, dont le fond est tourné du côté de la queue. Ces deux sacs sont les ovaires proprement dits. Ils viennent déboucher dans une matrice ou ovaire externe, qui paraît être une dilatation considérable de leur propre membrane."

entire organization. Leydig appears to be the first who recognized in the tail-fin of the Argulidæ their principal and proper respiratory organ, at the same time admitting that, as in the lower Crustacea in general, respiration is here also effected in a great measure by the thin integument of the body, especially on the large membranous head-shield*. Of some use for respiration are perhaps also the small leaf-like appendages which are sometimes developed (as in *A. purpureus*, and, according to Kröyer, in *Gyropeltis longicauda*) on the final segment of the trunk, and which seem to be analogous to the leaf-like dorsal plates in the Pandaridæ. The posterior surface of the last pair of legs is often more or less flattened out and widened; but this widening cannot functionally or morphologically be compared with the so-called branchial appendages on the extremities of the Branchiopoda. For the rest, the legs of the Argulidæ lack any trace of such appendages, but in other respects do not differ much from those of the Branchiopoda; and as it is with the Phyllopoda amongst these that they most agree in general habit, so it is accordingly the extremities of these which are most like the swimming-feet of the Argulidæ.

In order, however, not to overlook this likeness, we must not select for comparison such extremities as, by their conversion into "respiratory feet," have lost the typical form of organs of locomotion, but such as still present this form fully and completely. This is especially the case with the first pair of feet, or the so-called swimming-feet, in *Apus*. They consist (in *Apus cancriformis*) of a three-jointed prolonged basal part, which at its extremity bears three long, inconspicuously jointed *swimming-branches* or *flagella*). These parts evidently correspond both in form and function to the three-jointed stem of the feet in the Argulidæ, together with the swimming-branches and "flagella" attached to the end of this. The sole difference is that this "flagellum" in the Argulidæ is bent upwards and inwards; but even this is not always the case; for in *A. funduli* it is, according to Kröyer, directed similarly to the two swimming-branches. Sometimes the flagellum is wanting, as in *A. purpureus*. The two branchial appendages on the upper surface of the foot in *Apus*, as also a pair of flagelliform appendages situated on their lower surface, together with the so-called *masticatory piece* at their base, are, however, entirely wanting in the Argulidæ: the supposition that the flagellum in these corresponds to the branchial appendage of the Branchiopoda is consequently incorrect—a point which not only its attachment but also its form evidently show. Moreover the parts just mentioned are easily recognizable on the following pairs of feet

* *Loc. cit.* p. 338.

in *Apus*; but as the swimming-branches become gradually shorter and broader, while the branchial appendage proceeds in development, the likeness in form which the first pair of feet so strikingly shows to the swimming-feet of the Argulidæ decreases gradually with the likeness in function.

We may now pass on to a nearer examination of the grounds on which Kröyer* sought to prove that the Argulidæ are siphonostomous Copepoda most nearly related to the Caligidæ. His first argument is that *Gyropeltis* presents a transition between these two families in "certain essential particulars;" by which is meant that the species of that genus *lack a sting*, and have the first pair of foot-jaws of a *hooked form*, not developed into *sucking-cups*. To this it may be objected that the "sting" and sucking-cups are altogether peculiar to the Argulidæ: they neither occur again in Branchiopoda nor in Copepoda; and thus *Gyropeltis* might as well be said to form a passage to the *Apodidæ*, for instance, in the former order as to the Caligidæ in the latter, on account of its wanting these structures. Through the discovery of *Gyropeltis*, only two of the characters on which it would be possible to base the position of the Argulidæ as a separate order have lost their importance, inasmuch as they cease to be constant; but no reason whatever for the union of these animals with either of the two orders in question has hence been obtained. With respect moreover to the distinct form of the first pair of foot-jaws, these organs in *Gyropeltis* have only remained at that stage which belongs to *Argulus* in the larval condition.

Another reason for his view of the relation between the Argulidæ and the Caligidæ has been drawn by Kröyer from the structure of the *antennæ*: he endeavours, in fact, to identify the first pair of antennæ in the former with the second pair in the latter, on the ground of their functional agreement as fixing-organs. We have already had occasion to point out, on the ground of their development, the incorrectness of this view of their relations; and the Argulidæ demonstrate, in the fact that in them not the second, but the first pair of antennæ have become the fixing-organs, that they are widely separated from the Caligidæ and the other parasitic Copepoda. Kröyer further tries to show that *Argulus*, like the Caligidæ, has *two* pairs of foot-

* *Loc. cit.* pp. 25-29. I have not been able to see the force of the following objection against Zenker's separation of the Argulidæ from the Siphonostoma:—"Zenker expresses as the result of his researches, that *Argulus* must either form a separate order or be united with the Branchiopoda. But, in admitting this alternative, he necessarily allows that if *Argulus* may not be united with the Siphonostoma, neither may it be enrolled amongst the Branchiopoda; else why think of erecting a new order for this genus?"

jaws. This we are the less disposed to dispute since we regard two pairs of foot-jaws as belonging typically to all the lower Crustacean orders; whence it follows that this character leaves quite undetermined the question to which of these orders the Argulidæ belong.

As we have already shown, Kröyer has mistaken these parts so far as to regard the second pair of antennæ as being the first pair of foot-jaws, and the sucking-cups, or the true first pair, as the second. Kröyer has further, by drawing a parallel between the tail in the Argulidæ and the *genital ring* in the Caligidæ, thought it possible to establish a nearer affinity between these families. I have already pointed out the incorrectness of this comparison, and endeavoured to show that the tail of the Argulidæ corresponds to the entire tail, inclusive of the genital ring, in the Caligidæ and other Copepoda. This, however, is altogether foreign to the question how far the Argulidæ are Copepoda or Branchiopoda. The Branchiopoda have a jointed or unjointed tail like the Copepoda; and in many Phyllopoda (as, for instance, *Branchipus* and *Artemia*) the first caudal segments are much more subservient to the office of generation than in the Copepoda and *Argulus*, since they contain, as already mentioned, both testes and ovaria. Even among the Cladocera, which otherwise, with few exceptions (*Leptodera*, *Bythotrephes*), resemble the Argulidæ in their unsegmented tail, we have an example of this in *Leptodera hyalina* (of which, however, the male is unknown), in which animal the ovaries at least are situated in the anterior tail-segments*.

Kröyer further asserts that, since it is now known that the "sting" does not belong to the mouth-tube, the oral organs of the Argulidæ offer no difficulty to their union with the Siphonostoma. We have, however, shown that the only resemblance between the oral organs in the two groups is that the mouth forms a sucking-tube, as is the case so often amongst the parasitic Articulata, not only among Crustacea of different orders, but also among Insects and Arachnids. That this character is of extremely subordinate value in the determination of the systematic position of the Crustacea is shown by the circumstance, among others, that we are forced to unite in the order Copepoda forms with free oral organs and forms with these enclosed in a suctorial tube. Zenker, who showed the necessity of this, rightly observes, with respect to Milne-Edwards's subclass *Crustacés suceurs*, "Is the form of the mouth to be regarded as of such weight systematically in a case where parasitic habits call for and produce a certain determinate form dependent thereupon?"

* Lilljeborg, "Beskrifning öfver tvenne märkliga Crustaceer af ordningen Cladocera," Öf. af. K. Vetensk. Ak. Förh. 1860, p. 266.

Whether the animals be related or not, the structure of their mouth must necessarily be somewhat similar in appearance. Circumstances which are modified in correspondence with peculiar modes of life are not signs sufficient to determine original affinity; better as such are those taken from characters which are as far as possible independent of the peculiarities of habits and mode of life."

The presence, therefore, of a suctorial organ shows merely that *Argulus* is a parasitic Crustacean, but does not point out to which order it should be referred. With reference to the "sting," Kröyer says that it "assuredly corresponds to the poison-weapon in many of the lower Crustacea, both free-swimming Copepods (as *Cyclopsine castor*) and parasites, although peculiar both in form and position." As Kröyer here mentions *Cyclopsine castor*, which has no organ comparable to the sting of the Argulidæ, I suppose he means the so-called *shell-gland* (skalkörteln) which has not only been observed in *Argulus* and some Copepods*, amongst which is *Cyclopsine castor*, but which occurs generally in the Branchiopoda, both Phyllopoda and Cladocera†, in the Cytheridæ among the Ostracoda‡, and which is considered to be the same organ as that known as the *green gland* in Decapoda and Amphipoda. Meanwhile the determination of this "shell-gland" as a secretory and specially as a poison-organ is in the highest degree uncertain, and the more so since we do not as yet know for certain whether any channel exists in connexion with it. Zenker certainly insists that it opens externally in *Cythere* through a spine on the lower antennæ; and Kröyer has a similar suggestion where he says § that in the Caligidæ the claw on the second pair of antennæ "shows on the concave side very frequently (perhaps always) a bristle or fine spine, which seems to be connected with an extensive internal apparatus (gland, channel, and bladder)." But he continues thus:—"Whether this is to be referred to the category of the organs lately pointed out in many of the lower Crustacea, and designated *poison-weapon*, must be left undetermined," and adds that he "has often found a perfectly similar apparatus on the hooked second pair of feet,"—an addition which renders the propriety of a comparison with the "poison-organ" of, for instance, *Cyclopsine* very doubtful. If, meanwhile, these suggestions of Zenker and Kröyer are correct, and if the "shell-" or "poison-

* Zenker, "Ueber die Cyclopiden des süßsen Wassers," Archiv für Naturgeschichte, xx. (1854) p. 98; also Claus, *loc. cit.* p. 60.

† Leydig, Naturgeschichte der Daphniden, p. 23 &c.

‡ Zenker, "Monographie der Ostracoden," Archiv für Naturgeschichte, xx. (1854) pp. 18 & 29.

§ *Loc. cit.* p. 105.

gland" in *Argulus* opens through the "sting," which has not yet been attested from observation, then it is only the spine just mentioned on the second pair of antennæ in the Caligidæ and Cytheridæ (consequently in animals belonging to two different orders) which can be compared with the sting in *Argulus*. As the "poison-gland" itself occurs in many widely separated orders, it is easy to see that its presence in the Argulidæ in no way points out their zoological affinity; and should it open through a *spine* in some parasitic Copepoda, these would be in the same relation to *Cyclops* and *Cyclopsine* (which lack such an organ) as that which the parasitic *Argulus* with sting bears to the free Branchiopoda *without* sting.

Kröyer produces two further reasons for his view of the systematic position of the Argulidæ, which it now remains for us to remove. The first is "the absence in Argulidæ of external egg-sacs—which finds its analogy in the genera *Notodelphys*, *Doropygus*, &c." It seems to us, on the contrary, quite obvious that the absence of external egg-sacs goes to prove that the Argulidæ are *not* Copepods, since these, with the exception of the Notodelphyidæ and *Buprorus*, generally *have* external egg-sacs, as is also the case in particular with the Caligidæ and all the other *Siphonostoma* with which the Argulidæ would be ranged *were* they Copepods. The asserted analogy is, moreover, very feeble; for in the Argulidæ the eggs stand on the ovary itself until they attain freedom, whereas in *Notodelphys* &c. they pass from the ovaries into a matrix comparable with the so-called uterus in the Branchiopoda, or, still better, with the matrix of the Cladocera.

Kröyer finds the last attestation of the Copepod nature of the Argulidæ in "the simple eyes placed in a triangular form, which recur not only in the free-swimming Copepods (*Sapphirina*), but also in the parasites in the larval state." With reference to this, we have only to remark that an unpaired eye, retained after the larval period, without or with two, three, or several crystalline bodies ("simple eyes"), is quite usual, not only among the Copepoda (where it generally constitutes the sole visual organ), but also among Phyllopoda, Cladocera, and other lower Crustaceans, and that consequently the presence of such an eye in *Argulus* in no way proves its relationship to the Copepoda. Further, Kröyer's representation of the structure of this single eye in *Argulus* is incorrect; for what he calls three simple eyes are in that animal a three-lobed prolongation of the brain itself, bearing a *pigment-spot*, in which not a trace of crystalline bodies or "simple eyes" is to be detected, at least in either *A. foliaceus* or *A. coregoni*. The unpaired eye in many Branchiopoda (as *Branchipus* and *Artemia*) also shows itself as such a pigment-

spot, placed on a perfectly similar trilobed projection from the brain-ganglion*.

We have now gone through the proofs which have been put forward by Kröyer as grounds for the union of the Argulidæ with the siphonostomous Copepoda, and shown, we hope, that not one of them can be regarded as in any measure convincing or decisive. We will now briefly recapitulate the results to which we have been led during the foregoing investigation, and thence arrive at the conclusion respecting the systematic position of the Argulidæ which those results seem to warrant.

I. The Argulidæ *correspond* with the *Copepoda generally*, besides such points of their organization as are *common to the Branchiopoda and Copepoda*, only in these particulars:—that

- (1) The females possess *receptacula seminis*; and that
- (2) Parthenogenesis seems never to occur.

II. But they *differ* from the *Copepoda generally* in the circumstance that

(1) Their limbs want the intermediate plate (*mellanskifva*), and do not show the form characteristic of Copepoda; that

(2) They have two moveable eyes composed of numerous crystalline stemmata in front of the unsymmetrical larval eye; that

(3) The integuments of the head are developed into a bipartite shield, very often covering the larger portion of the body; that

(4) The eggs are neither attached to external egg-sacs nor are received into a matrix when they leave the ovaries; that

(5) Impregnation is not effected by means of spermatophores attached externally to the body of the female; and that

(6) The larvæ leave the egg in a much more advanced state of development than in the Copepoda.

III. Meanwhile they *agree* with the (higher) *siphonostomous Copepoda* in certain particulars, which all, however, *depend upon their parasitic mode of life*: they have, for instance,

- (1) A depressed body;
- (2) A pair of the antennæ modified as fixing-organs;
- (3) The mouth transformed into a sucking-tube; and
- (4) Strongly developed foot-jaws.

IV. They differ likewise from the *Siphonostoma* in the following points:—

(1) The *first*, not the second, pair of antennæ are the fixing-organs;

* Vide Leydig, *loc. cit.* p. 39 &c.

- (2) Palpi are wanting ;
- (3) A "sting" (gadd) is present in front of the mouth-tube ;
- (4) Two pairs of oral organs may be enclosed in this tube ;
- (5) The first pair of foot-jaws may have the form of sucking-cups.

V. The Argulidæ approach the *Branchiopoda* in general in

- (1) The fundamental form of their extremities ;
- (2) The structure of the visual organs ;
- (3) The tendency to a shell-structure, expressed in the shape of the head-shield ;
- (4) The absence of palpi ;
- (5) The absence of external egg-sacs ; and
- (6) The absence of external spermatophores.

VI. To the *Phyllopoda* in particular they make an approach in

- (1) The conspicuous segmentation of the trunk ;
- (2) The non-fusion of the symmetrical eyes into a single eye.

VII. To the *Cladocera* in particular they make an approach in

- (1) The small number of the extremities ; and
- (2) The unsegmented tail.

VIII. They stand midway between the *Phyllopoda* and the *Cladocera* by virtue of

- (1) Their mode of development.

IX. From both *Phyllopoda* and *Cladocera* they differ in the following points :—

- (1) They are organized for a parasitic existence ;
- (2) The extremities are entirely without branchial appendages ;
- (3) The tail is transformed into a respiratory plate ;
- (4) The generative apparatus shows some peculiarities, particularly the presence of receptacula seminis ;
- (5) The eggs are ejected immediately after quitting the ovary ;
- (6) Parthenogenesis seems never to occur.

A glance over this sketch of the relations of the Argulidæ to the Copepoda on the one side, and to the Branchiopoda on the other, will, we think, lead to the conviction that the Argulidæ cannot possibly be referred to the first-mentioned order, but that, on the contrary, they approach the Branchiopoda through such important characters that their reception amongst these must be regarded as fully warrantable. In our estimation, the Argulidæ are *parasitic* Branchiopoda ; and consequently we cannot share the view that they ought to constitute a *separate order*, in spite of the many points in which, as we have shown above, they differ from both Phyllopoda and Cladocera. Thus the characters which are both necessary and sufficient for de-

fining strictly the limits of the Branchiopoda among the other lower Crustaceans—the compound eyes with unfacetted cornea, the absence of palpi or branchial appendages on the oral organs, lobed or cloven respiratory or swimming-feet without median plates, distinct sexes—occur in the Argulidæ. The discrepancies which depend on their parasitic habits cannot be put forward as reasons for the isolated position of the Argulidæ, at least as long as parasitic and free Copepoda are unanimously referred to the same order. If we look at these differences, we find that between the Argulidæ on the one side, and the Phyllopoda and Cladocera on the other, no greater dissimilarities exist than those which separate these two groups from each other. Although indeed it must be admitted that the Argulidæ stand nearer to the Phyllopoda than to the Cladocera, it seems to us nevertheless that the differences we have mentioned (we would recall in particular the form and function of the tail, and the presence of receptacula seminis), in conjunction with the characters which are correlative to their parasitic nature, are sufficiently strong to set aside the notion of the introduction of the Argulidæ among the Phyllopoda. We regard them consequently as a group of the same systematic value as these and the Cladocera—that is to say, a *suborder*, on a par with these, in the order of the Branchiopoda,—and propose, since *Argulidæ* or *Argulina* are only suitable as family names, for this suborder the appellation *Branchiura*, drawn from the characteristic condition of the tail in these animals. Just as the Cladocera are composed of one family only (the Daphnidæ), the Branchiura for the present comprise only one family (the Argulidæ).

We think that the Branchiopoda (if we reserve the fossil Trilobites, which undoubtedly belong to them, and with whose oral organs and feet we are not sufficiently acquainted) may be characterized as follows:—

BRANCHIOPODA.

Oris partes palpis fere semper carentes, appendicibus branchialibus nullis; maxillarum par 1-0, maxillipedum 2-0. Oculi duo magni laterales, sæpe in unum coaliti, e multis bacillis crystallinis compositi, cornea supra æquali præditi. Segmentorum et pedum numerus valde varians: pedes fissi vel foliacei, appendicibus branchialibus plerumque instructi, nulla lamina intermedia bini conjuncti. Corpus testa membranacea, plerumque bivalvi, sæpissime inclusum. Sexus distincti.

I. PHYLLOPODA.

Oculi compositi plus minus sejuncti. Pedum paria 10-60. Metamorphosis completa. Libere natantia.

1. BRANCHIPODIDÆ. 2. APODIDÆ. 3. LIMNADIDÆ. 4. NEBALIDÆ.

II. CLADOCERA.

Oculi compositi in unum coaliti. Pedum paria 4-6. Metamorphosis nulla. Libere natantia.

1. DAPHNIDÆ.

III. BRANCHIURA.

Oculi compositi sejuncti. Pedum paria 4. Metamorphosis incompleta. Parasitantia.

1. ARGULIDÆ.

[To be continued.]

XXXVI.—On a new Species of Beech-Marten from Formosa.

By ROBERT SWINHOE, H.B.M. Consul at Taiwan.

WHEN I read my paper "On the Mammals of the Island of Formosa" before the Zoological Society (December 9, 1862), I noted that I had not at that time been made aware of the existence of any species of *Mustela* in the island. Since then, from the mountains of the interior towards the south, I have procured, through my hunters, a fine species of forest-Marten, which is perhaps the handsomest animal that I have had the good fortune to obtain. Dr. J. E. Gray's invaluable epitome of the known species of the *Mustelidæ* (Proc. Zool. Soc. Jan. 24, 1865) has enabled me to determine, without much troublesome research, that the Formosan animal is an undescribed species. The Formosan Marten has, as might be expected, its nearest ally in *Martes flavigula* (Bodd.), of the Nepal Hills. I would propose to distinguish our species as the

Martes chrysospila.

Head blackish brown, the hairs on the occiput being tipped with white. Centre of inside of ear white. Chin, sides of head, throat, and central streak of underneck also white. Sides of neck a fine bright golden colour. Body, above and below, bright purplish brown, becoming nearly black on hind quarters, hind legs, and tail. Fore legs blackish brown, pale down their fronts. Claws whitish. Length, from muzzle to base of tail, $20\frac{1}{2}$ inches; from base of tail to tip of hairs at its end, 17 inches. Top of shoulder to tip of fore foot about 8 inches.

Habitat. Mountain-forests of central Formosa.

Martes flavigula is thus briefly described by Dr. Gray, in the paper above referred to: "Yellowish; head, nape, rump, legs, and tail black; chin and lower parts white." I cannot remark on the difference of the cranium and dentition of the two species, as I have no specimen of the Nepalese species to compare with.

Amoy (China), June 22, 1866.